RESTRICTED

ORDNANCE PAMPHLET NO. 945

RANGE TABLE

FOR

20-MM. A. A. GUN

2,725 F. S. INITIAL VELOCITY

A BUREAU OF ORDNANCE PUBLICATION

25 AUGUST 1943

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Acting Chief of Bureau

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6 December 1944
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RANGE TABLE FOR 20 MM A.A. GUN

Page 1: In the second line of paragraph 1 under General Information change 2740 to 2770.

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ORDNANCE PAMPHLET NO. 945

20-MM. RANGE TABLE

1. Ordnance Pamphlet No. 945 contains information on the flight of 20-mm. projectiles for use in controlling the fire of 20-mm. antiaircraft guns against aircraft.

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W. H. P. Blandy,
Rear Admiral, U. S. Navy,
Chief of the Bureau of Ordnance.

TD Ruddock

T. D. Ruddock,
Acting.

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INTRODUCTION

GENERAL INFORMATION

1. This range table is applicable to 20-mm projectiles, H. E. Mark 3, H. E. I. Mark 3, and H. E. T. Mark 7. In a new gun with 90° powder the initial velocity with these projectiles will be 2,740 feet per second. An initial velocity of 2,725 feet per second was used in preparing this range table.

2. The standard air density at the surface of 1.2034 kilograms per cubic meter corresponds to a temperature of 59° F., a barometric pressure of 29.53 inches and a humidity of 78 percent. The standard air density aloft is given in Bureau of Aeronautics publication, N. Aer. 440, 1942, Instructions and Tables for Making Observations and Computing Ballistic Wind and Ballistic Density.

PART I

SURFACE RANGE TABLE

EXPLANATORY NOTES

1. Columns 1 to 8 give the elements of the standard trajectories.

2. Columns 10 to 19 give the differential effects due to variations from standard conditions. In these columns the effects are proportional to the variations. For example, the effect on range of a 10-knot wind is tabulated in column 13. The effect of a 20-knot wind may be obtained by multiplying the tabular values by 2.

3. Column 10 may be used to determine the change in range due to either plus or minus variations in initial velocity.

4. The effect on range due to a variation from standard air density is given in column 12 which is properly entered with ballistic density.

5. When ballistic density is not available but surface temperature and pressure are known, range corrections corresponding to an average ballistic density may be obtained from figure 1.

6. Column 12 also gives the effect on range of ±10 percent variation in the ballistic coefficient.

7. Columns 13 and 16 give the effects of a 10-knot ballistic wind. When, however, no measured or estimated ballistic wind is available the surface true wind must necesssarily be used in entering these columns.

8. Column 19 shows how much the point of impact is raised or lowered on a vertical screen by raising or lowering the sight bar 100 yards, the actual range remaining fixed.

9. The change in range due to a variation of ±1 minute in the angle of elevation may be deduced from column 2b.

10. The maximum range of this gun occurs at approximately 35° elevation. At elevations between 35° and 45° the range will remain practically constant.

Range	Angle of elevation			Increase in angle of elevation for 100 yards increase in range	Angle of fall		Time of flight	Striking velocity	Drift	Danger space for a target 20 feet high	Maximum ordinate
1	2		2a	2b	3		4	5	6	7	8
Yards	°	′	*Minutes*	*Minutes*	°	′	*Seconds*	*F. S.*	*Yards*	*Yards*	*Feet*
100		2	2	2		3	0. 11	-----	0. 1	100	-----
200		4	4	2		6	. 23	-----	. 3	200	-----
300		6	6	3		10	. 36	-----	. 5	300	-----
400		9	9	4		14	. 50	-----	. 7	400	-----
500		13	13	4		19	. 66	1, 839	. 9	500	2
600		17	17	5		26	. 84	-----	1. 1	600	-----
700		22	22	5		35	1. 03	-----	1. 3	700	-----
800		27	27	7		46	1. 24	-----	1. 6	800	-----
900		34	34	8		59	1. 47	-----	1. 9	900	-----
1, 000		42	42	9	1	15	1. 71	1, 212	2. 2	1, 000	13
1, 100		51	51	9	1	32	1. 96	-----	2. 5	1, 100	-----
1, 200	1	00	60	10	1	51	2. 23	-----	2. 8	293	-----
1, 300	1	10	70	10	2	12	2. 52	-----	3. 1	222	-----
1, 400	1	20	80	11	2	36	2. 83	-----	3. 5	182	-----
1, 500	1	31	91	13	3	03	3. 16	928	3. 9	152	45
1, 600	1	44	104	14	3	32	3. 50	-----	4. 2	129	-----
1, 700	1	58	118	15	4	03	3. 85	-----	4. 6	110	-----
1, 800	2	13	133	16	4	36	4. 22	-----	5. 1	94	-----
1, 900	2	29	149	17	5	11	4. 61	-----	5. 6	81	-----
2, 000	2	46	166	19	5	49	5. 01	773	6. 1	70	110
2, 100	3	05	185	20	6	30	5. 43	-----	7	61	-----
2, 200	3	25	205	22	7	14	5. 86	-----	7	53	-----
2, 300	3	47	227	23	8	01	6. 31	-----	8	46	-----
2, 400	4	10	250	24	8	51	6. 78	-----	8	41	-----
2, 500	4	34	274	26	9	44	7. 27	660	9	37	240
2, 600	5	00	300	28	10	41	7. 77	-----	10	34	-----
2, 700	5	28	328	29	11	43	8. 29	-----	11	31	-----
2, 800	5	57	357	31	12	51	8. 82	-----	12	28	-----
2, 900	6	28	388	33	14	06	9. 37	-----	13	26	-----
3, 000	7	01	421	35	15	28	9. 95	567	14	24	440

Change of range for variation of +10 feet per second initial velocity	Change of range for variation of — pounds in weight of projectile	Change of range for variation in density of air of −10 percent	Change of range for wind component in plane of fire of 10 knots	Change of range for motion of gun in plane of fire of 10 knots	Change of range for motion of target in plane of fire of 10 knots	Deviation for lateral wind component of 10 knots	Deviation for lateral motion of gun perpendicular to line of fire, speed of 10 knots	Deviation for lateral motion of target perpendicular to line of fire, speed of 10 knots	Change in height of impact for variation of 100 yards in sight bar
10	11	12	13	14	15	16	17	18	19
Yards	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Feet*
1	------	2	0	1	1	0. 1	0. 5	0. 6	0
2	------	5	0	1	1	. 2	1. 1	1. 3	1
2	------	8	0	2	2	. 3	1. 7	2. 0	1
3	------	12	0	3	3	. 4	2. 4	2. 8	1
3	------	16	0	4	4	. 6	3. 1	3. 7	2
3	------	20	1	4	5	. 8	3. 9	4. 7	2
4	------	25	1	5	6	1. 2	4. 6	5. 8	3
4	------	31	2	5	7	1. 8	5. 2	7. 0	4
5	------	38	3	5	8	2. 5	5. 8	8. 3	5
5	------	44	4	6	10	3. 3	6. 4	9. 7	7
5	------	51	6	5	11	4. 2	6. 9	11. 1	8
6	------	58	8	5	13	5. 1	7. 5	12. 6	10
6	------	66	9	5	14	6. 1	8. 1	14. 2	12
6	------	74	11	5	16	7. 2	8. 7	15. 9	14
6	------	81	13	5	18	8. 4	9. 4	17. 8	16
6	------	88	15	5	20	9. 7	10. 0	19. 7	19
6	------	95	17	5	22	11. 1	10. 6	21. 7	21
6	------	102	19	5	24	12. 6	11. 2	23. 8	24
6	------	108	22	4	26	14. 2	11. 8	26. 0	27
6	------	115	24	4	28	15. 8	12. 4	28. 2	31
6	------	121	27	4	31	18	13	31	34
6	------	128	29	4	33	19	14	33	38
6	------	134	32	4	36	21	15	36	42
6	------	141	35	3	38	23	15	38	47
6	------	148	38	3	41	25	16	41	52
6	------	155	41	3	44	28	16	44	57
6	------	162	44	3	47	30	17	47	62
6	------	169	47	3	50	32	18	50	68
6	------	176	50	3	53	35	18	53	75
6	------	184	54	2	56	37	19	56	83

Range	Angle of elevation		Increase in angle of elevation for 100 yards increase in range	Angle of fall		Time of flight	Striking velocity	Drift	Danger space for a target 20 feet high	Maximum ordinate
1	2		2a	2b	3		4	5	6	7	8
Yards	°	′	*Minutes*	*Minutes*	°	′	*Seconds*	*F. S.*	*Yards*	*Yards*	*Feet*
3,000	7	01	421	35	15	28	9.95	567	14	24	440
3,100	7	36	456	38	16	56	10.56	-----	15	22	-----
3,200	8	14	494	41	18	30	11.19	-----	16	20	-----
3,300	8	55	535	44	20	09	11.85	-----	18	18	-----
3,400	9	39	579	47	21	54	12.54	-----	19	17	-----
3,500	10	26	626	50	23	45	13.27	491	21	15	790
3,600	11	16	676	54	25	43	14.04	-----	23	14	-----
3,700	12	10	730	58	27	50	14.84	-----	25	13	-----
3,800	13	08	788	63	30	07	15.68	-----	27	11	-----
3,900	14	11	851	69	32	35	16.57	-----	30	10	-----
4,000	15	20	920	76	35	15	17.51	450	32	9	1,340
4,100	16	36	996	85	38	09	18.52	-----	35	8	-----
4,200	18	01	1,081	96	41	19	19.61	-----	38	8	-----
4,300	19	37	1,177	110	44	47	20.82	-----	41	7	-----
4,400	21	27	1,287	131	48	35	22.19	-----	44	6	-----
4,500	23	38	1,418	164	52	45	23.81	480	48	5	2,310
4,600	26	22	1,582	294	57	20	25.86	-----	52	4	-----
4,700	31	16	1,876	------	63	04	29.30	-----	58	3	-----
4,734	35	19	2,119	------	68	20	31.74	686	62	3	3,840

Change of range for variation of +10 feet per second initial velocity	Change of range for variation of — pounds in weight of projectile	Change of range for variation in density of air of −10 percent	Change of range for wind component in plane of fire of 10 knots	Change of range for motion of gun in plane of fire of 10 knots	Change of range for motion of target in plane of fire of 10 knots	Deviation for lateral wind component of 10 knots	Deviation for lateral motion of gun perpendicular to line of fire, speed of 10 knots	Deviation for lateral motion of target perpendicular to line of fire, speed of 10 knots	Change in height of impact for variation of 100 yards in sight bar
10	11	12	13	14	15	16	17	18	19
Yards	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Yards*	*Feet*
6	---	184	54	2	56	37	19	56	83
6	---	192	57	2	59	40	19	59	91
6	---	200	61	2	63	43	20	63	100
6	---	208	65	2	67	46	21	67	110
6	---	216	69	2	71	49	22	71	121
6	---	225	73	2	75	53	22	75	132
6	---	234	77	2	79	56	23	79	144
6	---	242	82	2	84	60	24	84	158
6	---	251	86	2	88	64	24	88	174
6	---	260	91	2	93	68	25	93	192
6	---	270	97	2	99	73	26	99	212
6	---	280	102	2	104	78	26	104	236
6	---	290	108	2	110	83	27	110	264
6	---	300	115	2	117	89	28	117	298
6	---	311	122	3	125	96	29	125	340
6	---	322	130	4	134	103	31	134	395
6	---	334	140	6	146	113	33	146	468
6	---	348	157	8	165	130	35	165	590
6	---	357	170	9	179	143	36	179	755

PART II

ANTIAIRCRAFT RANGE TABLE DATA

EXPLANATORY NOTES

These tables give elements of the standard trajectories tabulated against slant range and angle of position. Elevation is defined as the angle between the axis of the bore and the horizontal plane at the gun. The line of position of a point is the straight line connecting the gun with that point. Slant range is the distance from the gun to the point measured along the line of position. The horizontal range and altitude are, respectively, the horizontal and vertical components of the slant range. Angle of position is the angle between the line of position and the horizontal plane at the gun. Sight angle is the difference between elevation and angle of position.

TIME OF FLIGHT AND SIGHT ANGLE

Slant range	Time of flight	Position angle, degrees																	
		0		5		10		15		20		25		30		35		40	
Yds.	*Sec.*	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′
100	0.11	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	1	0	1
200	.23	0	4	0	4	0	4	0	4	0	4	0	4	0	3	0	3	0	3
300	.36	0	6	0	6	0	6	0	6	0	6	0	6	0	5	0	5	0	5
400	.50	0	9	0	9	0	9	0	9	0	9	0	8	0	8	0	7	0	7
500	.66	0	13	0	13	0	12	0	12	0	12	0	11	0	11	0	10	0	10
600	.84	0	17	0	17	0	16	0	16	0	16	0	15	0	15	0	14	0	13
700	1.03	0	22	0	22	0	21	0	21	0	21	0	20	0	19	0	18	0	17
800	1.24	0	27	0	27	0	27	0	26	0	26	0	25	0	24	0	23	0	21
900	1.47	0	34	0	34	0	34	0	33	0	32	0	31	0	29	0	28	0	26
1,000	1.71	0	42	0	42	0	42	0	41	0	40	0	38	0	36	0	34	0	32
1,100	1.96	0	51	0	51	0	50	0	49	0	48	0	46	0	44	0	41	0	39
1,200	2.23	1	0	1	0	0	59	0	58	0	56	0	54	0	52	0	49	0	46
1,300	2.52	1	10	1	10	1	9	1	7	1	5	1	3	1	0	0	57	0	53
1,400	2.83	1	20	1	20	1	19	1	17	1	15	1	13	1	9	1	5	1	1
1,500	3.16	1	31	1	31	1	30	1	28	1	26	1	23	1	19	1	15	1	10
1,600	3.50	1	44	1	43	1	42	1	40	1	38	1	34	1	30	1	25	1	19
1,700	3.85	1	58	1	57	1	56	1	54	1	51	1	47	1	42	1	36	1	30
1,800	4.22	2	13	2	12	2	11	2	9	2	5	2	0	1	55	1	49	1	42
1,900	4.61	2	29	2	28	2	27	2	24	2	20	2	15	2	9	2	2	1	54
2,000	5.01	2	46	2	45	2	43	2	40	2	36	2	31	2	24	2	16	2	7

TIME OF FLIGHT AND SIGHT ANGLE

Position angle, degrees																			
45		50		55		60		65		70		75		80		85		90	
°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′
0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
0	3	0	2	0	2	0	2	0	2	0	1	0	1	0	1	0	0	0	0
0	4	0	4	0	4	0	3	0	3	0	2	0	2	0	1	0	1	0	0
0	6	0	6	0	5	0	5	0	4	0	3	0	2	0	2	0	1	0	0
0	9	0	8	0	7	0	6	0	5	0	4	0	3	0	2	0	1	0	0
0	12	0	11	0	10	0	8	0	7	0	6	0	4	0	3	0	2	0	0
0	15	0	14	0	13	0	11	0	9	0	7	0	6	0	4	0	2	0	0
0	19	0	18	0	16	0	14	0	11	0	9	0	7	0	5	0	2	0	0
0	24	0	22	0	20	0	17	0	14	0	12	0	9	0	6	0	3	0	0
0	30	0	27	0	24	0	21	0	18	0	14	0	11	0	7	0	4	0	0
0	36	0	32	0	29	0	25	0	21	0	17	0	13	0	9	0	4	0	0
0	42	0	38	0	34	0	30	0	25	0	20	0	15	0	10	0	5	0	0
0	49	0	44	0	40	0	35	0	29	0	24	0	18	0	12	0	6	0	0
0	56	0	51	0	46	0	40	0	34	0	27	0	21	0	14	0	7	0	0
1	4	0	59	0	53	0	46	0	39	0	31	0	24	0	16	0	8	0	0
1	13	1	7	1	0	0	52	0	44	0	35	0	27	0	18	0	9	0	0
1	23	1	16	1	8	0	59	0	50	0	40	0	30	0	20	0	10	0	0
1	34	1	26	1	17	1	7	0	56	0	45	0	34	0	23	0	12	0	0
1	45	1	36	1	26	1	15	1	3	0	51	0	38	0	26	0	13	0	0
1	57	1	46	1	35	1	23	1	10	0	57	0	43	0	29	0	15	0	0

ALTITUDE IN FEET

Slant range	Position angle, degrees																		
yds.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
100	0	26	52	78	103	127	150	172	193	212	230	246	260	272	282	290	295	299	300
200	0	52	104	155	205	254	300	344	386	424	460	491	520	544	564	580	591	598	600
300	0	78	156	233	308	380	450	516	579	636	689	737	779	816	846	869	886	897	900
400	0	105	208	311	410	507	600	688	771	849	919	983	1, 039	1, 088	1, 128	1, 159	1, 182	1, 195	1, 200
500	0	131	260	388	513	634	750	860	964	1, 061	1, 149	1, 229	1, 299	1, 359	1, 410	1, 449	1, 477	1, 494	1. 500
600	0	157	313	466	616	761	900	1, 032	1, 157	1, 273	1, 379	1, 474	1, 559	1, 631	1, 691	1, 739	1, 773	1, 793	1, 800
700	0	183	365	544	718	887	1, 050	1, 205	1, 350	1, 485	1, 609	1, 720	1, 819	1, 903	1, 973	2, 028	2, 068	2, 092	2, 100
800	0	209	417	621	821	1, 014	1, 200	1, 377	1, 543	1, 697	1, 839	1, 966	2, 078	2, 175	2, 255	2, 318	2, 364	2, 391	2, 400
900	0	235	469	699	923	1, 141	1, 350	1, 549	1, 736	1, 909	2, 068	2, 212	2, 338	2, 447	2, 537	2, 608	2, 659	2, 690	2, 700
1, 000	0	261	521	776	1, 026	1, 268	1, 500	1, 721	1, 928	2, 121	2, 298	2, 457	2, 598	2, 719	2, 819	2, 898	2, 954	2, 989	3, 000
1, 100	0	288	573	854	1, 129	1, 395	1, 650	1, 893	2, 121	2, 333	2, 528	2, 703	2, 858	2, 991	3, 101	3, 188	3, 250	3, 287	3, 300
1, 200	0	314	625	932	1, 231	1, 521	1, 800	2, 056	2, 314	2, 546	2, 758	2, 949	3, 118	3, 263	3, 383	3, 477	3, 545	3, 586	3, 600
1, 300	0	340	677	1, 009	1, 334	1, 648	1, 950	2, 237	2, 507	2, 758	2, 988	3, 195	3, 377	3, 535	3, 665	3, 767	3, 841	3, 885	3, 900
1, 400	0	366	729	1, 087	1, 436	1, 775	2, 100	2, 409	2, 700	2, 970	3, 217	3, 440	3, 637	3, 806	3, 947	4, 057	4, 136	4, 184	4, 200
1, 500	0	392	781	1, 165	1, 539	1, 902	2, 250	2, 581	2, 893	3, 182	3, 447	3, 686	3, 897	4, 078	4, 229	4, 347	4, 432	4, 483	4, 500
1, 600	0	418	834	1, 242	1, 642	2, 029	2, 400	2, 753	3, 085	3, 394	3, 677	3, 932	4, 157	4, 350	4, 511	4, 636	4, 727	4, 782	4, 800
1, 700	0	444	886	1, 320	1, 744	2, 155	2, 550	2, 925	3, 278	3, 606	3, 907	4, 178	4, 417	4, 622	4, 792	4, 926	5, 023	5, 081	5, 100
1, 800	0	471	938	1, 398	1, 847	2, 282	2, 700	3, 097	3, 471	3, 818	4, 137	4, 423	4, 677	4, 894	5, 074	5, 216	5, 318	5, 379	5, 400
1, 900	0	497	990	1, 475	1, 950	2, 409	2, 850	3, 269	3, 664	4, 031	4, 366	4, 669	4, 936	5, 166	5, 356	5, 506	5, 613	5, 678	5, 700
2, 000	0	523	1, 042	1, 553	2, 052	2, 536	3, 000	3, 441	3, 857	4, 243	4, 596	4, 915	5, 196	5, 438	5, 638	5, 796	5, 909	5, 977	6, 000

PART III

GRAPHICAL DATA

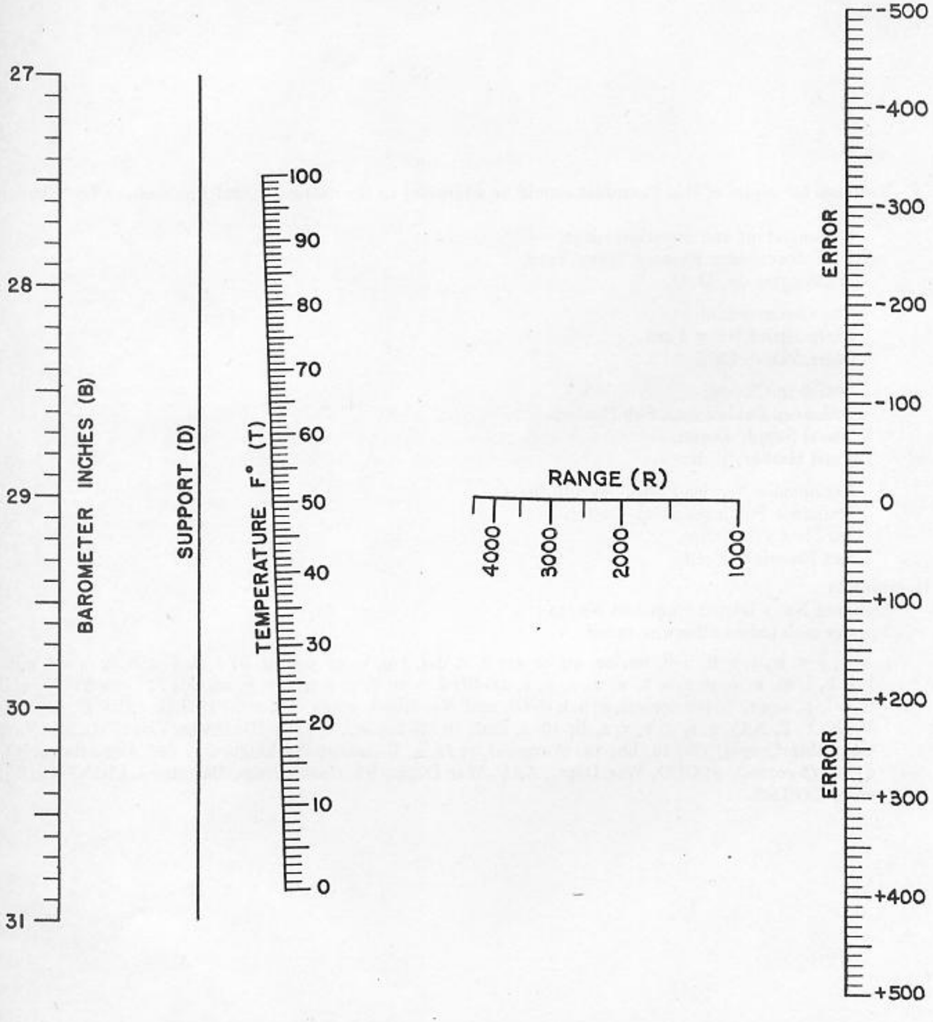
Figure 1

INSTRUCTIONS

Align B and T to get point on support D.
Align D with R to get error in yards due to change in density of air.

Example:
Given—Barometer inches =28. 9
Temperature degrees F. =85
Range yards =3, 000
Result—Error yards =+135

NOTE: The best estimate of ballistic density to different altitudes is in very close, but not in exact, agreement with standard density when surface conditions are standard. When surface density is not standard, the disagreement is usually greater and is a function of surface density and maximum ordinate. The use of figure 1 will not give agreement with results obtained from column 12 and surface observations only, but should be a more accurate figure, in that it takes into account the ratio between mean measured and standard density for the actual maximum ordinate obtained.



CHANGE IN RANGE FOR VARIATION IN DENSITY OF AIR

FOR SURFACE TARGETS

Figure 1.

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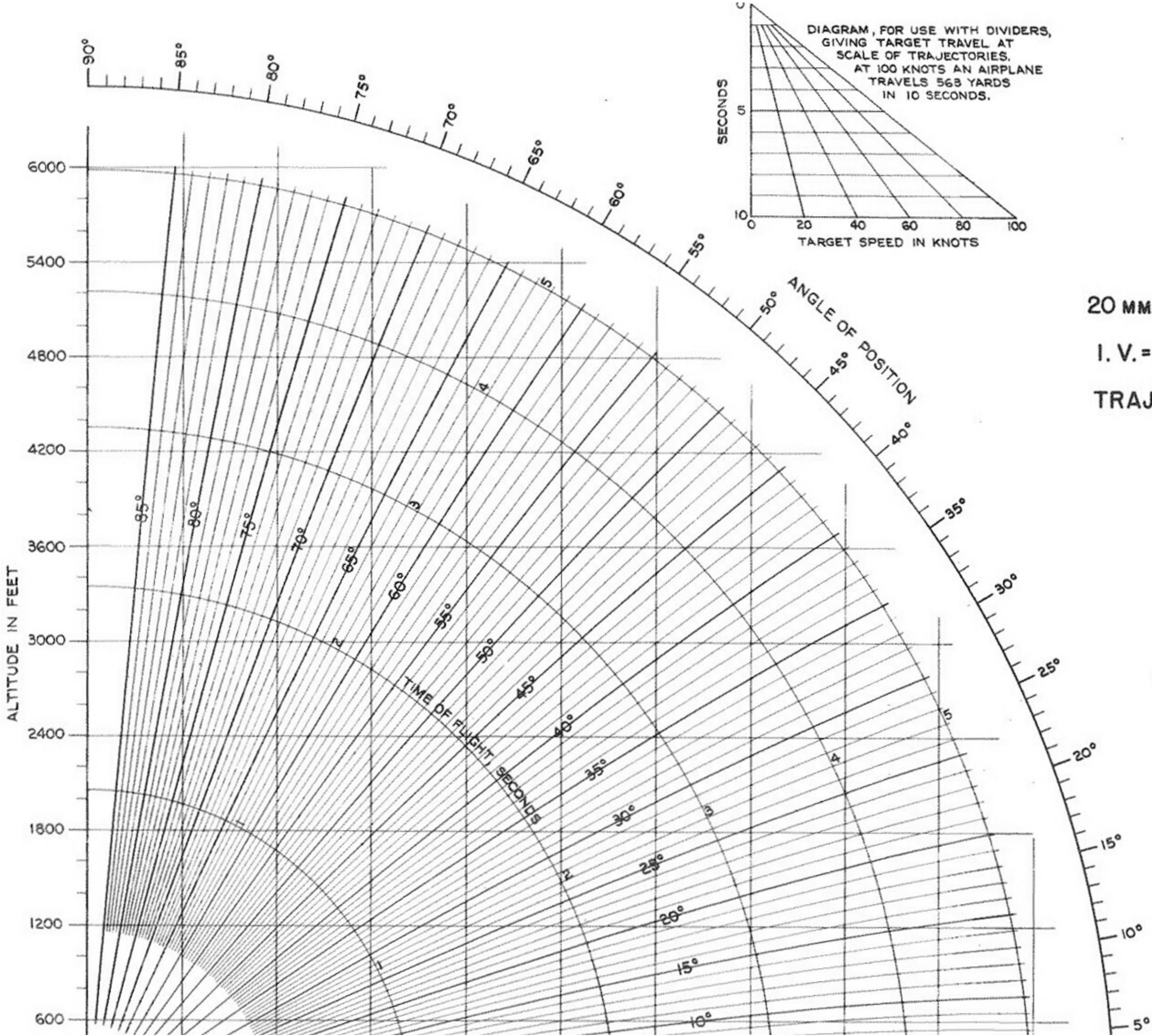
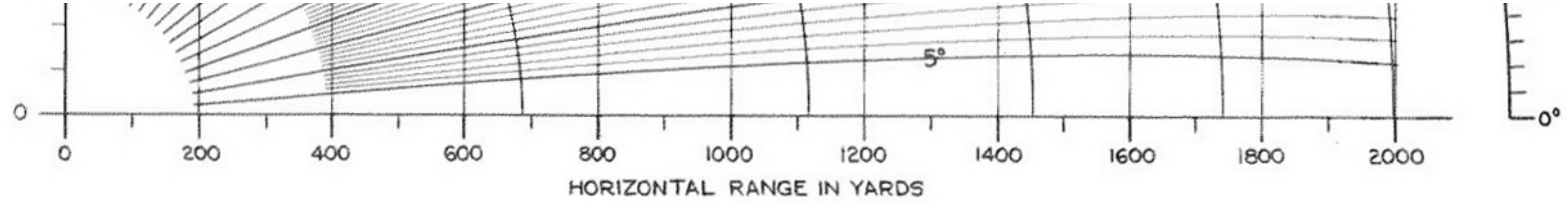


DIAGRAM, FOR USE WITH DIVIDERS,
GIVING TARGET TRAVEL AT
SCALE OF TRAJECTORIES.
AT 100 KNOTS AN AIRPLANE
TRAVELS 563 YARDS
IN 10 SECONDS.

20 MM. A.A. GUN

I.V. = 2725 F.S.

TRAJECTORIES


5°
0°
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
HORIZONTAL RANGE IN YARDS

(Face p. 12.)